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Examining Market Power in the Finnish Dairy Chain

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Master's thesis

Agricultural Economics

Department of Economics and Management

University of Helsinki

February 2017

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Faculty Faculty of Agriculture and Forestry	**Department** Department of Economics and Management	
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Title Examining Market Power in the Finnish Dairy Chain		
Subject Agricultural Economics		
Level Master's thesis	**Month and year** 2/2017	**Number of pages** 56 + 4 (Appendices)

Abstract

This study examined whether dairy processors and retailers have market power in the Finnish dairy chain, and the analysis was limited to the wholesale and the retail market of dairy products. The study of industrial organization and new empirical industrial organization provided methodological framework for the study. Market power has been extensively studied in other dairy chains but attempts to estimate market power in the Finnish dairy chain are few. Market power in the Finnish dairy chain has not been examined with a bilateral oligopoly approach before. The approach allows relaxing the presumptions about price taking. Because the dairy processing and the retail sector in Finland are highly concentrated, presumptions about price taking would have been too restrictive.

The results indicate that retailers have market power over consumers but the wholesale market is competitive. According to the results, retailers employ full mark-up in the retail market, and the market is thus characterized by collusive behavior. A need for further research is emphasized. Because the current evidence is scarce, cumulative evidence through further research would be needed.

Keywords

bilateral oligopoly, market power, new empirical industrial organization, Finnish dairy chain

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UNIVERSITY OF HELSINKI

Tiedekunta/Osasto	Laitos
Maatalous-metsätieteellinen tiedekunta	Taloustieteen laitos

Tekijä

Juho Valtiala

Työn nimi

Examining Market Power in the Finnish Dairy Chain

Oppiaine

Maatalousekonomia

Työn laji	Aika	Sivumäärä
Maisterintutkielma	2/2017	56 + 4 (liitteet)

Tiivistelmä

Tässä tutkimuksessa selvitettiin, onko meijeriteolisuudella ja vähittäiskaupalla markkinavoimaa suomalaisessa maitoketjussa? Analyysi rajoittui tukku- ja kuluttajamarkkinoihin. Epätäydellisen kilpailun teoria sekä uusi empiirinen toimialatutkimus loivat tutkimukselle teoreettisen perustan. Markkinavoimaa on eri maiden maitoketjujen osalta tutkittu paljon, mutta suomalaista maitoketjua on tältä osin tutkittu hyvin vähän. Suomen maitoketjua ei ole aiemmin tutkittu mallilla, jossa lähtökohdaksi otetaan bilateraalinen oligopoli. Siinä markkinamuotoa ei tarvitse olettaa etukäteen. Meijeriteollisuus sekä vähittäiskauppa ovat Suomessa erittäin keskittyneitä toimialoja, minkä vuoksi rajoittavia ennakko-oletuksia markkinamuodosta ei haluttu tehdä.

Tulosten mukaan vähittäiskaupalla on markkinavoimaa kuluttajiin nähden, mutta tukkumarkkinat ovat kilpailulliset. Kuluttajamarkkinoilla hinnoittelulisän suuruudeksi saatiin korkein mahdollinen lukema, mikä viittaa kollusiiviseen toimintaan markkinoilla. Jatkotutkimuksen tarvetta korostetaan. Koska nykyinen tutkimustieto aiheesta on vähäistä, on tutkimustiedon määrää tärkeää kasvattaa lisätutkimuksen kautta.

Avainsanat

bilateraalinen oligopoli, markkinavoima, uusi empiirinen toimialatutkimus, suomalainen maitoketju

Säilytyspaikka

Helsingin yliopiston kirjasto – Helda / E-thesis (opinnäytteet) ethesis.helsinki.fi

Muita tietoja

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List of Abbreviations

ADF	Augmented Dickey–Fuller
BPT	Bilateral price-taking
GMM	Generalized method of moments
IO	Industrial organization
MMSC	Model and moment selection criteria
MPT	Manufacturer price-taking
NEIO	New empirical industrial organization
NST	Nested
RPT	Retailer price-taking
SCP	Structure-conduct-performance

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1 Introduction

As the food prices soared in 2007–08, public interest and criticism were shown towards the performance of the Finnish food chain. Especially, concentration in retail sectors and consequent decrease in the degree of competition has been a concern around Europe. It seems evident that the concentration has impacted food prices negatively. On the other hand, concentrated retail sector provides counterbalance to concentrated food industry. (Björkroth et al. 2012.) In the context of the Finnish food chain, the degree of concentration is distinctive in the retail and the dairy processing sector. During 2007–09, the producer and the consumer price of dairy products increased more on average in Finland than in Eurozone. The evidence suggests that the degree of competition decreased in processing and in wholesale of dairy products during 2001–07. (Kotilainen et al. 2010.)

Concentration in certain market is often associated with market power, but concentration is not necessary caused by the decreased degree of competition. Before drawing conclusions about concentration and market power, presence and the degree of market power should first be proven. (Briones & Rakotoarisoa 2013.) New Empirical Industrial Organization (NEIO) framework has been widely used to measure the degree of market imperfections. It has been applied to various industries, yet food industry has been studied most extensively. (Kaiser & Suzuki 2006, 4.)

Only few studies have attempted to measure the degree of market power in the Finnish dairy chain. Ulvinen (2006) concluded that processing, the wholesale and the retail sector are competitive despite the high degree of concentration. Čechura, Žáková Kroupová and Hockmann (2015) studied oligopoly power of European dairy processing sectors and provided estimates for Finland among other countries. In their approach, NEIO was combined with the stochastic frontier analysis. Market power in the Finnish dairy chain has not been examined with a bilateral oligopoly approach before. The approach allows relaxing the presumptions about price taking.

In the Finnish dairy chain, the wholesale–retail sector was able to increase its share from the consumer price by nearly four percent during 2008–12, whereas the share of the dairy industry remained unchanged. In the dairy chain, processing sector has stronger position towards wholesale–retail sector than in other food chains in Finland. On the other hand, increased production of private label products has caused revenues to transfer from the processing sector to the wholesale–retail sector. (Peltoniemi et al. 2015.)

In this study, the Finnish dairy chain was analyzed. Retail and independent wholesale firms are considered as a joint sector in the context of the empirical analysis. Word retail sector, or retailer, thus refers to both if wholesale sector, or wholesaler, is not explicitly mentioned. Wholesale market, on the other hand, refers to the market between processors and retailers and retail market to the market between retailers and consumers. The objective of the study was to examine market power between dairy processors and retailers, and to determine whether retailers have market power over consumers. The analysis was limited to the wholesale and the retail market of dairy products. Another aim was to estimate the degree of market power if detected. NEIO provided methodological framework for the study. The approach by Schroeter et al. (2000) was applied in the empirical analysis.

The rest of the report is organized as follows. Chapter 2 presents the methodological framework and basic concepts concerning imperfect competition. Previous studies about market power in dairy chains are introduced in Chapter 3. A review on the development and the current state of the dairy processing and the retail sector in Finland is also provided. Chapter 4 presents the approach used in the empirical analysis as well as methods and data used in the estimation. The results are presented in Chapter 5 and Chapter 6 provides conclusions and discussion.

2 A Review on Framework for the Study of Market Power

In economic theory, Industrial Organization (IO) refers to the study of imperfect competition (Cabral 2000, 3). The first section provides the definition of IO and presents its history briefly. It also provides the definition of market power and discusses the implications of market power. The second section presents the elementary theory about profit maximization under imperfect competition and strategic interaction between firms. The third section discusses the NEIO paradigm.

2.1 Industrial Organization and Market power

According to Cabral (2000, 3), IO studies the performance of markets and industries with an emphasis on how firms compete. Kaiser and Suzuki (2006, 5) emphasize that the motivation of IO is to provide political guidance. Tirole (1990, 3), on the other hand, avoids defining IO exactly, but he emphasizes the role of market structure and the behavior of firms in the paradigm.

The history of IO begins from the so-called Harvard tradition. One of the founding assumptions in this tradition was that market structure determines market conduct, e.g. prices and investments. Market conduct eventually leads to performance which is observed through profits or the ratio between the price and the marginal cost. Because of these three causal parts, the paradigm is known as Structure-Conduct-Performance (SCP). It was empirical by nature and aimed to explain performance measures with the structure and conduct variables, e.g. concentration ratios and advertising to sales ratios. This approach was contested by more theoretical approach, known as Chicago tradition. Still, the study of IO was about to renew. There was dissatisfaction towards the empirical work of the earlier IO, and interest among economic theorists towards IO was increasing in 1970s. A new tradition began to form and it was theoretical by nature. It adapted game theory as a unified framework for the analysis. (Tirole 1990, 1–3.)

Kaiser and Suzuki (2006, 5–6) discuss the political motivation of the previous approaches. Although both Harvard and Chicago tradition considered perfect competition as a benchmark, they disagreed on how markets should be guided towards competitive equilibrium. According to the Harvard tradition, a policy restricting the concentration of industry improved welfare and was necessary for a market to reach competitive equilibrium. The Chicago tradition, on the other hand, advocated a view which stated that markets, even with one firm, adjust towards competitive equilibrium, and government interventions only disturb this adjustment.

According to Cabral (2000, 6) the object of IO reduces to market power. He specifies four questions to be answered. First, is there any market power? Second, how is market power acquired and maintained? Third, are there implications from market power? Fourth, how should market power be regulated? Cabral (2000, 7) mentions two ways to acquire market power: legal protection from competition and strategic interaction. On the other hand, Pindyck and Rubinfeld (2013, 375–387) name three sources for market power: number of firms, strategic interaction between firms and elasticity of demand or supply.

Market power is defined as the ability of seller or buyer to affect prices in a market. Under perfect competition, an individual firm does not have such ability, but the price is determined by the supply and the demand in the market. Market power is also known as monopoly power when sellers are concerned and, respectively, as monopsony power in the case of buyers. In reality, most firms have at least some market power. In technical terms, price exceeds the marginal cost of production when market power is present. This difference between the price and the marginal cost is known as mark-up, or mark-down in the case of buyer. (Pindyck & Rubinfeld 2013, 357–388.)

The societal implications of market power are ambiguous. It is beneficial for a firm to have market power, but higher price implies transfer from consumers to firms. In general, market power implies inefficiency in several ways. The quantity is smaller which causes society to be worse-off. For a given price, the optimal output is lower for a firm with market power than for a firm in a perfectly competitive market. Facing less competition, firms in an imperfectly competitive market also have less incentive to improve efficiency. Market power may cause rent seeking which means that firms use their resources to maintain their market power. For a society, it proves to be unproductive. (Cabral 2000, 8–9.) Firms may do rent seeking in several ways. They may promote laws which prevents or complicates entering the market. They may also promote laws which grant them market power. Resources may also be used for legal services which aim to prevent accusations concerning misuse of market power. Surplus capacity can be built to make entering the market seem less attractive. (Pindyck & Rubinfeld 2013, 378–379.)

On the other hand, market power can enhance welfare through technological development. Cabral (2000, 292–295) reminds that, although firms with market power have less incentive to invest in research and development, large firms proved to be the main source of technological progress. They have more resources to invest into research and development. According to Cabral, the ultimate optimality implies some degree of market power in the short run and continuous adjustment towards perfect competition in the long run.

2.2 Profit Maximization and Strategic Interaction under Imperfect Competition

This section presents the profit maximization of a firm under imperfect competition. At first, strategic interaction between firms is ignored and monopolistic competition is assumed. In this case, market demand determines the price and the quantity for an oligopolistic firm. Respectively, the supply determines the price and the quantity for an oligopsonistic firm. If a firm has market power, it can, in theory, choose either the price or the quantity and take the other as given. Thus, changing the quantity will change the price and vice versa. Because of this relation, the marginal revenue of an oligopolistic firm or the marginal cost of an oligopsonistic firm is not constant. Marginal revenue and marginal cost are presented in terms of algebra in Equation 1.

$$\Delta r = \Delta c = p\Delta q + q\Delta p \tag{1}$$

In Equation 1, r denotes revenue, c denotes cost, p denotes price and q denotes quantity. Term Δ means that the previous value is subtracted from the current value. If quantity can only be changed, price is presented as the function of quantity, i.e. inverse demand function. If the difference is considered as a small increase, it can be expressed as a derivative. (see e.g. Varian 2006, 277–283 & 423–425.)

An oligopolistic firm adjusts the amount of production and an oligopsonistic firm adjusts the amount of inputs it buys. The optimum for an oligopolistic firm implies that the marginal revenue from an output equals the marginal cost of producing the output.

The input demand of a buyer is also known as the marginal expenditure. In the case of an oligopsonistic firm, the marginal revenue from an input should equal the marginal cost of the input. By rearranging the terms in Equation 1 and by presenting differences as derivatives, profit maximization condition is obtained (Equation 2).

$$mc = mr = \frac{\partial r}{\partial q} = p + \frac{\partial p}{\partial q} q \tag{2}$$

In Equation 2, *mc* refers to marginal cost and *mr* to marginal revenue. Equation 3 shows the profit maximization condition after the rearrangement of the terms in Equation 2.

$$mc = mr = \frac{\partial r}{\partial q} = p\left(1 + \frac{1}{\varepsilon}\right) \tag{3}$$

In Equation 3, term ε denotes the elasticity of demand or supply depending on the context. (see e.g. Varian 2006, 424–425 & 471–473.)

Equation 3 implies that the marginal revenue equals to the price only when ε is infinitely large. As the elasticity grows, mark-up or mark-down decreases and market performance moves towards perfect competition. In the case of an oligopolistic firm, ε denotes the elasticity of demand. The term is negative in this case so the marginal revenue must be less than or equal to the price. This implies further that the quantity under imperfect competition is smaller than or equal to the quantity under perfect competition. If the quantity is smaller, the price is higher, and therefore the price under imperfect competition is higher than or equal to the price under perfect competition. In the case of an oligopsonistic firm, ε denotes the elasticity of supply. The term is positive so the marginal revenue is greater than or equal to the price. In this case, the equilibrium quantity is smaller than or equal to the quantity under perfect competiton, and the equilibrium price is lower than or equal to the price under perfect competition. This is illustrated in Figure 2. (see e.g. Pindyck & Rubinfeld 2013, 368–388; Varian 2006, 424–425 & 471–473.)

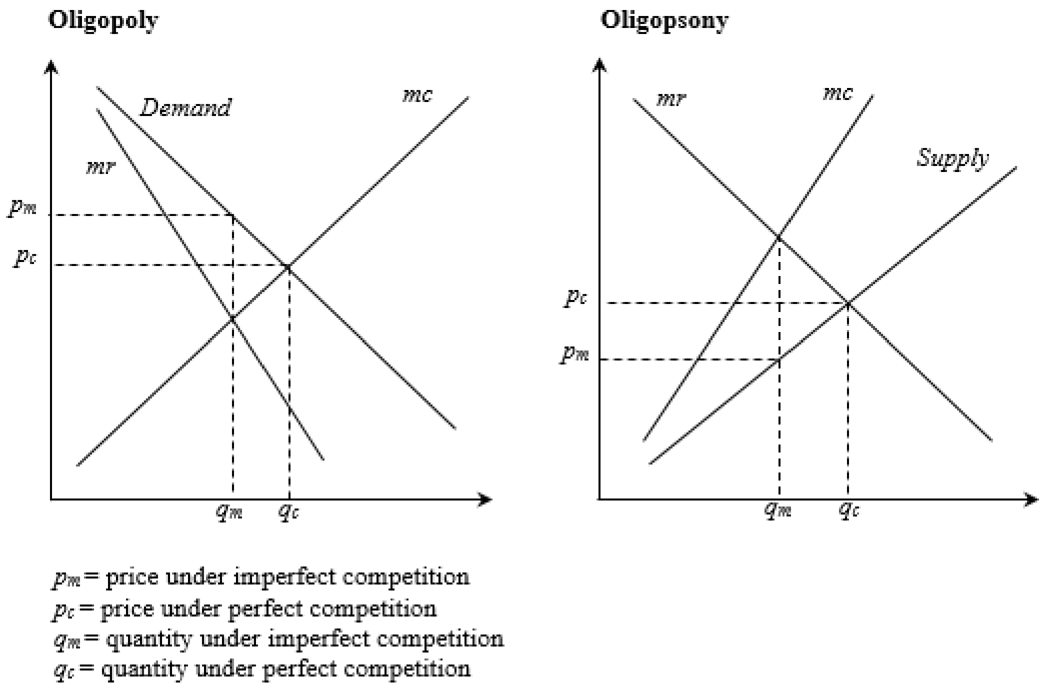

Figure 1. Market equilibrium in case of oligopoly and oligopsony

Game theory has been used to model strategic interaction between firms. In the basic game setting, firms are making decisions concerning only price or quantity. If one firm dominates the market, the game is sequential by nature. The dominating firm chooses its quantity or price first and other firms make their decisions based on that choice. If no dominant firm exist, it is reasonable to assume that firms make their decisions simultaneously based on their expectations. Simultaneous quantity setting is known as the Cournot model and simultaneous price setting as the Bertrand model. One possible outcome is collusion in which firms cooperate to maximize total profits in a market. (Varian 2006, 480–498.)

The Cournot model is presented more closely because it will be further applied in the context of the NEIO models. Let $q = y_i + \sum_{j \neq i} y_j$ be the total output and $p(q) = p\left(y_i + \sum_{j \neq i} y_j\right)$ the price. Because the output decision of a firm is dependent on the decisions of other firms, the output of firm i is expressed as a reaction function $y_i = f\left(\sum_{j \neq i} y_j\right)$. The profit maximization condition of firm i is $p(q) + \frac{\partial p}{\partial q} y_i = mc(y_i)$. If multiplied by $\frac{q}{q}$, the condition becomes $p(q)\left(1 + \frac{\partial p(q)}{\partial q} \frac{q}{p(q)} \frac{y_i}{q}\right) = mc(y_i)$. By denoting $\frac{y_i}{q}$ by s_i the condition takes the form shown in Equation 4.

$$p(q)\left(1+\frac{s_i}{\varepsilon(q)}\right)=mc(y_i) \qquad (4)$$

In the Cournot model, firms assume their rivals to continue producing the output they previously did. A single firm chooses the output based on the expected output of other firms. Because of this fundamental assumption, adjustment towards the equilibrium is a problematic concept in the Cournot model. Only at the equilibrium, where the reaction curves crosses, firms actually produce the expected output (Figure 2). Once the equilibrium is found, no firm find it profitable to change the output and the equilibrium is maintained. (Varian 2006, 480–498.)

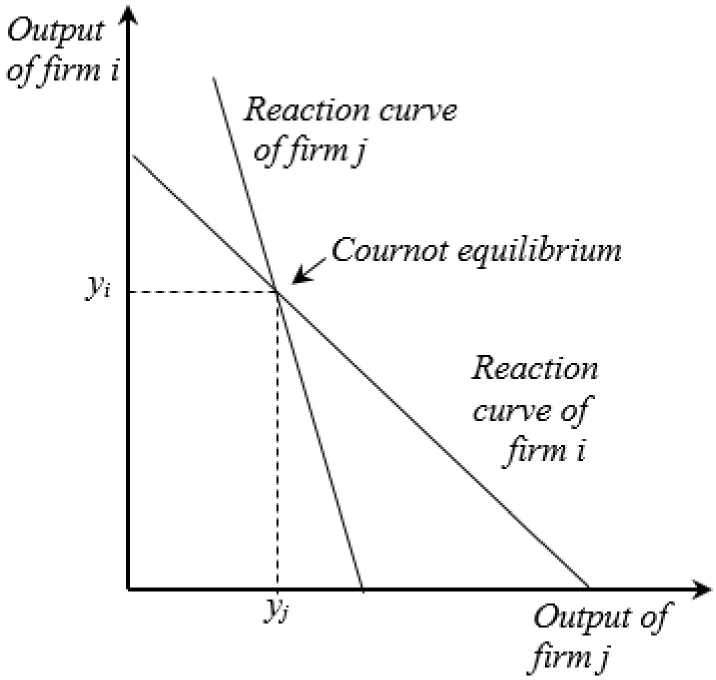

Figure 2. The reaction curves of two firms and the Cournot equilibrium

2.3 New Empirical Industrial Organization

New empirical industrial organization is an approach for measuring market imperfections. Because of its theoretical nature, the later IO did not contribute much to the empirical research and the IO models were not oriented to estimate welfare losses. NEIO, on the other hand, has strong emphasis on empirical research. In NEIO, the degree of market power is estimated directly using conduct parameters. The paradigm has generalized structural models to allow imperfect competition. (Kaiser & Suzuki 2006, 3–13)

Studies by Iwata (1974), Appelbaum (1982), Bresnahan (1982) and Lau (1982) are among the most influential pioneering works in NEIO. There are few fundamental differences between NEIO and SCP. While SCP applies accounting data to determine economic price-cost margins, NEIO does not consider the margins directly observable. Another major difference between the paradigms is that inference in SCP is always based on cross-sectional comparison, whereas NEIO focuses on a single industry. In a typical study, a single industry is analyzed using an econometric model which follows closely the economic theory. (Bresnahan 1989.)

Authors have discovered several ways to classify the NEIO models. Kaiser and Suzuki (2006, 13) distinguish two categories. First, there are the generalized Cournot models which are homogenous oligopoly settings in which quantity serves as the strategic variable. Secondly, there are the generalized Bertrand models in which products are differentiated and price serves as the strategic variable. Sheldon and Sperling (2003) classify the models into two approaches. In the so-called production theoretic approach, a system with three equations is estimated. A system includes a production, a cost and a demand function. In the so-called general identification method, only two equations are required implying that the price elasticity is not constant. Roy, Kim and Raju (2006) on the other hand, name two popular methods. The conjectural variations method is based on conduct parameters, and the menu approach is based on comparison of the models.

In NEIO, the empirical models include a conduct parameter which shows the degree of market power. To derive the parameter, consider the quantity setting problem shown in Equation 5.

$$\max_{y_i} r(y_i) = p\left(y_i + \sum\nolimits_{i \neq j} y_j(y_i)\right) y_i - c(y_i) \tag{5}$$

Term $r(y_i)$ denotes firm i 's revenue function, and $c(y_i)$ is the respective cost function. Using the previous notation, the first order condition for profit maximization is shown in Equation 6.

$$\frac{\partial r}{\partial y_i} = p(q) + \frac{\partial p(q)}{\partial q}\left(1 + \frac{\partial \sum_{i \neq j} y_j}{\partial y_i}\right) y_i - \frac{\partial c(y_i)}{\partial y_i} = 0 \tag{6}$$

Term $\frac{\partial \sum_{i \neq j} y_j}{\partial y_i}$ expresses the conjectural variations. It shows how much the total output of other firms change as one firm changes its output. Term $\left(1 + \frac{\partial \sum_{i \neq j} y_j}{\partial y_i}\right)$ equals $\frac{\partial q}{\partial y_i}$. When further elaborated, Equation 6 becomes $\frac{\partial c(y_i)}{\partial y_i} = p(q) + \frac{\partial p(q)}{\partial y_i}\left(\frac{\partial q}{\partial y_i}\frac{y_i}{q}\right)\frac{q}{p(q)}p(q)$. Denote term $\left(\frac{\partial p(q)}{\partial q}\frac{q}{p(q)}\right)$ by $\frac{1}{\varepsilon}$ and term $\left(\frac{\partial q}{\partial y_i}\frac{y_i}{q}\right)$ by θ_i. The latter is known as the conjectural elasticity. The obtained profit maximization condition is shown in Equation 7.

$$\frac{\partial c(y_i)}{\partial y_i} = p(q)\left(1 + \frac{\theta_i}{\varepsilon}\right) \tag{7}$$

Parameter θ, which indicates the degree of market power, can have values between zero and one. If zero, the right-hand side of Equation 7 reduces to *p(q)*. In this case, a market proves perfectly competitive. If the value of the parameter is one, a market is monopoly or collusion. Intermediate values imply that the structure of a market lies between perfect competition and monopoly. (Kaiser & Suzuki 2006, 13–17.)

If Cournot behavior is assumed, the conjectural elasticity can be further elaborated. Term $\frac{\partial \sum_{i \neq j} y_j}{\partial y_i}$ becomes zero as firms do not expect anyone to change their output. This is shown in Equation 8.

$$p(q) + \left(\frac{y_i}{q}\right)\frac{1}{\varepsilon}p(q) = mc_i \tag{8}$$

After dividing by p and rearranging the terms, Equation 8 can be expressed as the Lerner index as shown in Equation 9.

$$\frac{(p - mc_i)}{p} = \frac{\theta_i}{\varepsilon} = L_i \tag{9}$$

Term L_i denotes the Lerner index value of firm i. If market shares are summed up and multiplied by the term $\frac{y_i}{q}$, the average value for a market is obtained. This is shown in Equation 10.

$$\frac{\left(p - \sum mc_i \frac{y_i}{q}\right)}{p} = \frac{\sum \theta_i}{\varepsilon}\frac{y_i}{q} = \frac{\theta}{\varepsilon} \tag{10}$$

The right-hand side of Equation 10 can also be written as the Herfindahl index as shown in Equation 11.

$$\frac{\sum \theta_i}{\varepsilon}\frac{y_i}{q} = \frac{\sum \left(\frac{y_i}{q}\right)^2}{\varepsilon} = \frac{H}{\varepsilon} \tag{11}$$

Term H denotes Herfindahl index which is the measure of market concentration. This result is consistent with Equation 4. If all firms have a similar marginal cost structure, the conjectural elasticity equals H. In this case, the inverse of the number of firms shows the degree of market power. (Kaiser & Suzuki 2006, 13–17.) Because the conjectural variations are dynamic by nature, the static models, which most of the NEIO models are, can be considered as logically inconsistent. This can be circumvented by giving parameter θ a generic interpretation, e.g. the measure of market power. (Perloff 1991.)

Despite the development of the models in NEIO, the shortage of proper data makes the empirical research challenging. Kaiser and Suzuki (2006, 347) note that most of the applied data in NEIO studies is highly aggregate over space, product and time. They recommend using more disaggregate data and emphasize that the optimal solution is to use firm level panel data. The sensitivity of the results causes another challenge. Perekhozhuk et al. (2016) show that the approach, functional form and statistical estimation method may have a substantial impact on results and propose presenting a comparison of different specifications and estimation methods in the study. They also note that most the NEIO models form nonlinear systems which frequently fail to converge. It is also reminded by Bresnahan (1989; see also Sheldon & Sperling (2003)) that, although NEIO has provided a way to measure market power, it has not been able to detect the causes of market power.

The models have become more sophisticated and more diverse. Rezitis and Kalantzi (2012) studied the food manufacturing industry in Greece. They applied a model which lends the idea of inter-industry comparison from the SCP studies and takes it to the NEIO context. The panel consisted of sectors in the Greek food industry and estimates were provided for each sector and for the food industry as a whole. Some studies aim to estimate market power simultaneously in more than one stage of the food chain. For example, Cakir and Balagtas (2012) employed double a mark-up model in which producers were allowed to have market power over a joint processing–retailing stage and that in turn over consumers. In the model applied by Moro, Sckokai and Veneziani (2012), processors were allowed to have market power over producers and retailers were allowed to have market power over both processors and consumers. Furthermore, this model estimated simultaneously the supply and demand of three meat products. Some studies aimed to combine NEIO with other paradigms. For example, Čechura et al. (2015) applied the stochastic frontier analysis in NEIO context, and Grau and Hockmann (2016) combined the time series techniques to NEIO.

Although several models allow market power in various stages, models allowing bilateral market power are not that common. Kaiser and Suzuki (2006, 345) emphasize the need to develop these models. The approach of Schroeter, Azzam and Zhang (2000) has been further applied by Kinoshita, Suzuki and Kaiser (2006) and Scalco and Braga (2015). Similar models have been developed inter alia by Raper, Love and Shumway (2000), Chung and Tostão (2012) and Park, Chung and Raper (2016).

3 A Review on Dairy Chains and Market Power

Market power in the dairy chains have been extensively studied using the NEIO models. Studies cover several dairy products and different parts of the chain. Some of the studies are presented in the first section. The second section provides insight to the Finnish dairy chain focusing on the dairy processing sectors. In addition to the current state and the structure of the dairy processing and the retail sector, the section presents some of the trends and major events which have had a substantial impact on the chain.

3.1 Market Power in Dairy Chains

Dairy chains have been of special interest in the NEIO literature. Perekhozhuk, Grings and Glauben (2009) studied oligopsony power in the Ukrainian dairy processing sector. They estimated the conduct both at the national and the regional level using monthly data which covered the period 1996–2003. They discovered no market power at the national level but rejected the hypothesis of perfect competition at the regional level. Two of the regional conduct parameters were significant at 10% level and two at 15% level. In these regions, prices were 3.6–46.7% lower than the value of the marginal product.

Similarly, Perekhozhuk et al. (2011) examined oligopsony power in the Hungarian dairy processing sector but the data was even more disaggregated. They applied plant-level panel data with 432 annual observations during 1993–2006. They discovered market power and the values of the conduct parameters were 0.22 and 0.3 in two out of four models. Cakir and Balagtas (2012) examined whether the federal regulations in the USA provided market power to the farmer co-operatives during 2000–07. The data comprised statistics from ten federal milk marketing order regions. They discovered that farmer cooperatives had approximately 9% mark-up while the joint processing–retailing stage had less than 1% mark-up.

Scalco and Braga (2014) studied oligopsony power of the dairy processors in Brazil. The regional level data with monthly observations covered the period 1997–2011. The conduct parameters were close to zero thus indicating no evidence for market power. Another study by Scalco and Braga (2015) examined the market of UHT milk in Brazil. The model allowed bilateral market power in the wholesale market. The data consisted of 66 observations covering the period 2004–09. They discovered that the retailers have market power over the processors but not over the consumers. The processors have no market power. The value of the conduct parameter was around 0.638. They concluded that the market is far from perfect competition.

Sckokai et al. (2013) estimated market power of the retailers in the case of two Italian quality cheeses. The model allowed retailers to have market power over both processors and consumers. They considered the period 2002–08, and there were 84 observations in the data set. They found that the retailers have market power over the consumers but not over the processors in the case of the Parmigiano-Reggiano cheese. The conduct parameter was 0.25 on average. Mérels (2009) also studied market power concerning quality cheeses. He examined whether the processors had oligopoly power in the market of the Comté cheese during 1985–2005. No market power was found.

The study by Čechura, Žáková Kroupová and Hockmann (2015) examined whether the European dairy sectors have oligopoly power. They had panel data which covered the period 2003–12. They provided estimates for the Finnish dairy sector, and the mark-up related to Finland was among the highest. They concluded that the degree of market power is modest on average. The average mark-up was 0.121 in the EU and 0.15 in Finland. They also examined whether the development of mark-up follows some linear trend. The average trend was decreasing but the mark-up increased in Finland during the period.

The Finnish studies concerning market power in the domestic dairy chain are few. Two studies were found but neither used a NEIO model. Kotilainen et al. (2010) examined the development of food prices and market performance in Finland. The period under consideration was 2001–07. The dairy processing and the dairy wholesale sector were examined more thoroughly. Profitability and concentration in the sectors was measured with six different indicators. They discovered that the competition in the dairy processing and the dairy wholesale sector diminished during the period. They also discovered that the profitability in both the sectors was lower than the average profitability of the sectors in the EU. They did not, however, provide any estimates concerning market power. On the other hand, Ulvinen (2006) found no evidence for market power in the dairy processing, the food wholesale and the retail sector despite the high level of concentration. She estimated the Lerner-index values for 2003 which were lower than 0.05 in all the sectors.

3.2 The Dairy Processing and the Retail Sector in Finland

The dairy processing sector has been highly significant part of the Finnish food industry. It has developed considerable value-added products, and dairy products has been the only group of food products with positive trade balance throughout the EU era. (Jansik, Niemi & Toikkanen 2015; see also Peltoniemi et al. 2015.) According to Jansik (2014), however, the future of the sector remains uncertain because the increasing level of competition and imports may cause domestic production to decrease in the era after the milk quota system.

In the beginning of the 20th century, the cooperative ideology was adopted from Denmark. Cooperatives became popular for various reasons which were mainly patriotic and economical. The dairy processing sector went through considerable changes. Previously, most of the dairies were privately-owned and located at manors. However, a remarkable number of cooperative dairies were founded when the ideology became widely known. (Korhonen 1998, 47–56.) Valio, the biggest dairy firm in Finland, was incorporated as a central organization in 1905 by 17 dairy cooperatives. A year later, it had 80 dairies as members, and the number of members peaked in 1938 when there was 563 members. (Perko 2005, 12.) In 2014, the company was, again, owned by 17 dairy cooperatives. According to its statistics, it collects around 85% of the milk produced in Finland. (Valio 2014.)

Some structural indicators for the dairy processing sector are presented in Table 1. The turnover is presented in the monetary values of the 2000. The number of enterprises has followed a declining trend, while the trend in the number of employees has been increasing. On the other hand, the amount of milk has mostly declined, while the turnover of the sector has mostly increased. These trends indicate the increase in the degree of concentration and the higher value-added of the production.

Table 1. The selected key figures for the Finnish dairy processing sector

	Enterprises	Turnover	Employees	Received milk (million liters)
2000	88	1726	4978	2371
2005	74	1743	4644	2293
2008	71	2121	5031	2188
2012	59	2213	5342	2188
2014	61	2154	5708	2289

Source: Statistics Finland a & Luke

Currently, the sector is dominated by cooperatives, and almost all the raw milk produced in Finland is collected by dairy cooperatives. Besides Valio, also Hämeenlinnan Osuusmeijeri, Maitomaa and Satamaito, which are considerable dairy firms in Finland, are owned by dairy cooperatives. Another remarkable firm in the market is Arla which is a subsidiary company of Arla Foods. Originally, there was Ingman Foods, a privately-owned Finnish dairy firm, and it was first partially and later completely bought by Arla Foods. (Arla.) The parental company Arla Foods is currently the fifth largest dairy firm in the world (Arla Foods). Kaslink Foods and Juustoportti are significant privately-owned firms. Nestlé and Unilever produce most of the Finnish ice-cream. The Finnish share from the total turnover in the Baltic Sea region has decreased, and the domestic dairy firms have lost their shares to foreign firms in the Finnish market (Jansik, Irz & Kuosmanen 2014). Table 2 presents some of the largest dairy firms in Finland and their market shares in 2014. Valio held 69.2% of the market and Arla slightly over 15%. Together they held 84.3% of the total revenue in the sector.

Table 2. Seven largest dairy firms in Finland and their market shares

	Turnover (M€)	Market share	Cumulative concentration	Employees
Valio	1714.0	69.2 %	69.2 %	3734
Arla	373.0	15.1 %	84.3 %	281
Hämeenlinnan Osuusmeijeri	69.5	2.8 %	87.1 %	82
Kaslink Foods	58.1	2.3 %	89.4 %	111
Maitomaa	54.5	2.2 %	91.6 %	52
Maitokolmio	42.3	1.7 %	93.3 %	80
Satamaito	46.3	1.9 %	95.2 %	57
Whole industry	2476.5	100.0 %	100.0 %	4902

Source: Statistics Finland a & Kauppalehti

Recently, the sector went through two considerable events. In 2012, Finnish Competition and Consumer Authority accused Valio of predatory pricing in fluid milk products and imposed a considerable penalty payment to the company. The authority was able to prove that Valio aimed to drive Arla Ingman out from the market by setting its prices below the production costs. This also forced smaller companies to set their prices the unprofitable level. (Kilpailuvirasto 2012.) Another considerable event was the trade embargo against Russia in 2014. In 2013, the sector made its record in revenue and in exports to Russia. Nevertheless, dairy products were most affected as the food exports were suspended. (Jansik, Niemi & Toikkanen 2015).

Concentration in the Finnish retail sector has grown and currently two companies dominate the sector. Two trends can be recognized in Finnish food retail. Firstly, the number of outlets and the amount of revenue have grown in the sector of specialized food retail. Secondly, discount stores and private label products have become more popular due to increased price sensitivity. The share of private labels has grown rapidly in dairy products. In addition, the threat of imports and narrowed selection have increased competition among the suppliers and decreased their margins. (Jansik, Niemi & Toikkanen 2015.)

Since 1990, the structure of the Finnish retail sector has changed substantially (Table 3). K-group was the dominating firm then, and the rest of the market was mostly shared by three smaller companies. In 2005 however, S-group had grown bigger than K-group, and their common market share reached almost 70%. Concentration has increased further, and the common share was 78.6% in 2015. K-group was founded in 1940 as four regional wholesale companies merged as Kesko. The company does procurement, provides business support and coordinates cooperation of the shareholder-retailers. (Kesko 2016.) S-group, which is cooperative by nature, was founded in 1904. As Kesko, SOK Corporation was similarly founded to jointly procure, consult and coordinate regional cooperative facilities of the member retailers. (S-kanava.)

Table 3. The market shares of some Finnish retail companies in the selected years

	1990	**2005**	**2015**
K-group	40.5 %	33.9 %	32.7 %
S-group	15.9 %	35.9 %	45.9 %
T-group	23.8 %	-	-
Tradeka / Suomen Lähikauppa	14.4 %	10.8 %	6.4 %
Spar	-	6.2 %	-
Lidl	-	3.7 %	9.0 %
Others	5.4 %	9.5 %	6.0 %
CR2	64.3 %	69.8 %	78.6 %

Source: Finnish Grocery Trade Association (2016), Finnish Food Marketing Association and the Kehittyvä Kauppa magazine (2006) & Niilola et al. (2003)

4 Materials and Methods

In this chapter, the empirical analysis is described. The first section presents the approach. The second section provides a brief introduction to Generalized Method of Moments (GMM) which has been used in the statistical estimation. The section also presents the statistical diagnostic tests which have been used in the estimation. In the third section, issues related to the data and the variables are discussed.

4.1 The Approach Applied in the Analysis

The approach by Schroeter et al. (2000) was adopted for the empirical analysis. It is based on three basic market structures, and each structure is modelled as a nonlinear system of equations. The models are then compared. Quantity, wholesale price and retail price of dairy products are the endogenous variables of the models. The homogeneity of products and fixed-proportions transformations, e.g. transportation and storage in retail level, are assumed. The assumptions justify the same variable for quantity in wholesale and in retail market. In each of the models, retailers may have market power over consumers but there are three possible scenarios when it comes to the market power in wholesale market.

In the first structure, the wholesale market is assumed to be competitive. This structure is called Bilateral Price-Taking (BPT). In this case, the marginal revenue of retailers equals retail price if retailers have no market power over consumers. If retailers do have market power over consumers, their marginal revenue is lower than the retail price. The net marginal revenue of retailers determines their input demand. It is obtained by subtracting marginal revenue from marginal cost. The equilibrium condition for the wholesale market in the BPT model implies that the marginal cost of processors equals the net marginal revenue of retailers. This condition also determines the wholesale price.

In the second structure, processors are price takers while retailers are allowed to have market power over processors. This structure is called Manufacturer Price-Taking (MPT). Retailers face processors supply which is determined by the processors' marginal cost of production. If retailers have oligopsony power, their marginal expenditure is higher than the processors' marginal cost. In the MPT model, the equilibrium condition for the wholesale market implies that net marginal revenue of processors equals their marginal expenditure. The wholesale price is determined by the marginal cost of processors.

In the third structure, retailers are price takers while processors are allowed to have market power over retailers. This structure is called Retailer Price-Taking (RPT). Processors face the input demand of retailers which is determined by the net marginal revenue of retailers. If processors have oligopoly power, their marginal revenue is lower than the net marginal revenue of retailers. In the RPT model, the equilibrium condition for the wholesale market implies that the marginal cost of processors equals their marginal revenue. In this case, the wholesale price is determined by the net marginal revenue of retailers.

The mathematical derivation of the models covers the rest of this section. The main steps of the calculation are provided here but more explicit derivation is provided in Appendix 1. Consider first the BPT model. The inverse consumer demand of dairy products is presented in Equation 12.

$$p_r = a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon \tag{12}$$

Term p_r denotes the retail price of dairy products in the Finnish market, q denotes the quantity of dairy products in the Finnish market, and variables x_2 and x_3 denote demand shifters. The interaction term is needed for the identification of the conduct parameter as Bresnahan (1982) and Lau (1982) have shown. Term ϵ is a stochastic error term. The marginal cost of the Finnish retailers is presented in Equation 13.

$$mc_r = b_0 + b_1 q + b_2 w_2 + \eta \tag{13}$$

Term w_2 is a cost shifter related to the retailers, and η is an error term. The marginal cost of the Finnish dairy processors is presented in Equation 14.

$$mc_p = c_0 + c_1 q + c_2 v_2 + c_3 v_3 q + \sum_{i=1}^{n} c_{0i} d_i + \mu \tag{14}$$

Variables v are cost shifters related to the processors, and μ is an error term. Variables $d_i, i = 1 \dots n$ are dummy variables which capture additional shocks in the supply. Schroeter et al. (2000) have shown that the interaction term is also needed in the processors' marginal cost equation for the market power to be identified.

The marginal revenue of retailers is presented in Equation 15.

$$mr_r = p_r + \lambda(a_1 + a_3x_3)q \tag{15}$$

The term λ is added in accordance with Equation 7, and it indicates the degree of the retailers' market power over the Finnish consumers. The net marginal revenue of retailers is presented in Equation 16. It is obtained by subtracting the Equation 13 from the Equation 15.

$$nmr_r = p_r + \lambda(a_1 + a_3x_3)q - b_0 - b_1q - b_2w_2 - \eta \tag{16}$$

The equilibrium condition in the BPT model implies that $mc_p = nmr_r$. Equaling Equations 14 and 16 and rearranging the terms yields the equilibrium condition which is presented in Equation 17.

$$\begin{aligned} p_r = -[\lambda(a_1 + a_3x_3) - (b_1 + c_1) - c_3v_3]q + (b_0 + c_0) + b_2w_2 + c_2v_2 \\ + \sum_{i=1}^{n} c_{0i}d_i + (\eta + \mu) \end{aligned} \tag{17}$$

The BPT system is completed by adding the supply and the demand equation which determine the retail and the wholesale price of dairy products. The processors supply implies that $p_w = mc_p$. Term p_w refers to the wholesale price of dairy products in the Finnish market. Equation 17, 12, and 14 thus form the BPT system.

The retailers' marginal expenditure for the MPT model is derived based on Equation 14. The marginal expenditure is presented in Equation 19 in which parameter δ indicates the degree of retailers' monopsony power.

$$me_r = c_0 + (1+\delta)(c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu \tag{18}$$

In the MPT model, the equilibrium condition for the wholesale market is $me_r = nmr_r$. The condition is obtained by equating Equation 16 and 18. The condition is presented in Equation 19.

$$\begin{gathered} p_r = -[\lambda(a_1 + a_3 x_3) - (b_1 + (1+\delta)c_1) - (1+\delta)c_3 v_3]q + (b_0 + c_0) \\ + b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu) \end{gathered} \tag{19}$$

The MPT system consists of Equation 19, 12, and 14. If δ is restricted to zero, the model reduces to the BPT model.

The processors' marginal revenue for the RPT model is derived based on Equation 16. The marginal revenue is presented in Equation 20 in which parameter γ indicates the degree of processors' monopoly power.

$$mr_p = nmr_r + \gamma\big((1+\lambda)(a_1 + a_3 x_3) - b_1\big)q \tag{20}$$

In the RPT model, the equilibrium condition for the wholesale market is $mc_p = mr_p$. The condition is obtained by equating Equation 14 and 20. The condition is presented in Equation 21.

$$\begin{gathered} p_r = -\big[\big(\gamma + \lambda(1+\gamma)\big)(a_1 + a_3 x_3) - (b_1(1+\gamma) + c_1) - c_3 v_3\big]q \\ + (b_0 + c_0) + b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu) \end{gathered} \tag{21}$$

In the RPT model, the wholesale price is determined by the retailers' input demand. The condition states that $p_w = nmr_r$. Equation 16 thus defines the wholesale price, and Equation 21 defines the retail price in the terms of the processors' marginal revenue.

Inserting Equation 21 to Equation 16 the wholesale price in the RPT model is obtained. This is shown in Equation 22.

$$p_w = -[\gamma(1+\lambda)(a_1 + a_3 x_3) - (b_1\gamma + c_1) - c_3 v_3]q + c_0 + c_2 v_2 + \sum_{i=1}^{n} c_{0i}\, d_i + \mu \tag{22}$$

The RPT system consists of Equation 21, 12 and 22. If γ is restricted to zero, the model reduces to the BPT model.

The BPT model can be derived from the MPT and the RPT model using parametric restrictions, but the MPT model cannot be derived from the RPT model by using parametric restrictions and vice versa. Schroeter et al. (2000) suggest creating an artificial model which nests the parameters to make this possible. In the nested (NST) system, the first equation is a synthetic combination of Equation 20 and 22. This is presented in Equation 23.

$$p_r = -\big[\big(\gamma + \lambda(1+\gamma)\big)(a_1 + a_3 x_3) - \big(b_1(1+\gamma) + (1+\delta)c_1\big) - c_3(1+\delta)v_3\big]q + (b_0 + c_0) + b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu) \tag{23}$$

The NST system consists of equations 23, 12 and 22. If the parameter δ is restricted to zero, the model reduces to the RPT model. Likewise, if the parameter γ is restricted to zero, the model reduces to the MPT model.

4.2 Statistical Estimation and Hypothesis Testing

The estimation was performed using GMM. It is a semiparametric method implying that distributional assumptions are removed. Semiparametric estimators are more robust than parametric estimators. In other words, semiparametric estimators retain important statistical properties, e.g. consistency, under fewer assumptions. However, if restrictive assumptions can be made concerning for example the distribution of the residuals, parametric methods provide more efficient estimators than semiparametric methods. (Greene 2003, 447.) The statistical estimation and testing was performed using Stata (version 13.0, Statacorp, College station, TX, USA).

Let $y_i = h(\boldsymbol{x}_i, \boldsymbol{\beta}) + \varepsilon_i$ be some estimated function which may be nonlinear. In the expression, term y_i denotes the i:th observation of the dependent variable, ε_i denotes an error term related to the i:th observation. Term $h(.)$ denotes the fitted value of the i:th observation as a function of independent variables $\boldsymbol{x}_i$ and K parameters $\boldsymbol{\beta}$. GMM is based on the orthogonality conditions which imply that the error terms should not correlate with the independent variables or pseudoregressors in the case of nonlinear regression. This condition is necessarily violated in the simultaneous equation estimation. The estimation needs to be made using instrumental variables which correlate with the independent variables but not with the error term, i.e. $E[\boldsymbol{z}_i \varepsilon_i | \boldsymbol{x}_i] = E\left[\boldsymbol{z}_i\left(y_i - h(\boldsymbol{x}_i, \boldsymbol{\beta})\right) | \boldsymbol{x}_i\right] = 0$. Term $\boldsymbol{z}_i$ is a vector of L instrumental variables. Empirical moment conditions for a single equation is presented in Equation 24. (Greene 2003, 533–547.)

$$\boldsymbol{m}(\boldsymbol{\beta}) = \frac{1}{n}\sum_{i=1}^{n} \boldsymbol{z}_i\left(y_i - h(\boldsymbol{x}_i, \boldsymbol{\beta})\right) = \frac{1}{n}\sum_{i=1}^{n} \boldsymbol{z}_i \varepsilon_i = 0 \tag{24}$$

If there are more moment conditions than parameters, the moment equations do not have a unique solution. The model is then said to be overidentified. In this case, the consistent and efficient estimator is found by minimizing the weighted sum of squares. The criterion function is thus a function of estimator $\boldsymbol{\beta}$ and optimal weighting matrix $\boldsymbol{W}$ (Equation 25).

$$q = \boldsymbol{m}(\boldsymbol{\beta})' \boldsymbol{W} \boldsymbol{m}(\boldsymbol{\beta}) \tag{25}$$

The optimal weighting matrix is the inversion of the asymptotic variance-covariance matrix of the empirical moment conditions. This is presented in Equation 26.

$$\boldsymbol{W} = \left(\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} Cov\left(\boldsymbol{z}_i\varepsilon_i, \boldsymbol{z}_j\varepsilon_j\right)\right)^{-1} = \left(\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \sigma_{ij}\, \boldsymbol{z}_i\boldsymbol{z}_j{}'\right)^{-1} = \left(\frac{1}{n}\boldsymbol{Z}'\boldsymbol{\Sigma}\boldsymbol{Z}\right)^{-1} \tag{26}$$

To allow autocorrelation in the error terms, $\boldsymbol{\Sigma}$ in Equation 26 can be expressed as Newey–West estimator as shown in Equation 27.

$$\boldsymbol{\Sigma} = \frac{1}{n}\sum_{j=1}^{n} \boldsymbol{z}_i\boldsymbol{z}_j{}'\varepsilon_i{}^2 + \frac{1}{n}\sum_{l=1}^{p} w(l) \sum_{i=l+1}^{n} \varepsilon_i\varepsilon_{i-l}(\boldsymbol{z}_i\boldsymbol{z}_{i-l}{}' + \boldsymbol{z}_{i-l}\boldsymbol{z}_i{}') \tag{27}$$

Term *w(l)* refers to some weight for a certain lag. Lags should be added until the autocorrelation is considered negligible. (Greene 2003, 533–547.) In the estimation, five lags were used which was the amount needed to make the overidentification test statistic and thus the impact of autocorrelation sufficiently small.

When more equations are estimated simultaneously, the criterion function can be presented in matrix form as shown in Equation 28.

$$q = \begin{bmatrix} \boldsymbol{m}(\boldsymbol{\beta}_1) \\ \boldsymbol{m}(\boldsymbol{\beta}_2) \\ \vdots \\ \boldsymbol{m}(\boldsymbol{\beta}_M) \end{bmatrix}' \begin{bmatrix} \boldsymbol{W}_{11} & \boldsymbol{W}_{12} & \cdots & \boldsymbol{W}_{1M} \\ \boldsymbol{W}_{21} & \boldsymbol{W}_{22} & \cdots & \boldsymbol{W}_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{W}_{M1} & \boldsymbol{W}_{M2} & \cdots & \boldsymbol{W}_{MM} \end{bmatrix} \begin{bmatrix} \boldsymbol{m}(\boldsymbol{\beta}_1) \\ \boldsymbol{m}(\boldsymbol{\beta}_2) \\ \vdots \\ \boldsymbol{m}(\boldsymbol{\beta}_M) \end{bmatrix} \tag{28}$$

The optimal weighting matrix consists of the variance-covariance matrices which are the covariances of the moment conditions among the equations. (Greene 2003, 409–410.)

Nonlinear systems are estimated using some numerical method. The Gauss-Newton algorithm was applied in the estimation because it was revealed to converge fast. The closed form solution for a nonlinear GMM estimator can be derived using the Gauss-Newton method. Following Hayashi (2000, 498), the moment conditions are first expanded as first-order Taylor series around some initial estimator $\widehat{\boldsymbol{\beta}}_i$. Using the previous notation, approximations for the empirical moments after one iteration are shown in Equation 29 in which $\boldsymbol{G}(\boldsymbol{\beta}) = \frac{\partial \boldsymbol{m}(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}'}$.

$$\begin{aligned} \boldsymbol{m}(\widehat{\boldsymbol{\beta}}_{i+1}) \approx \boldsymbol{m}(\widehat{\boldsymbol{\beta}}_i) + \boldsymbol{G}(\widehat{\boldsymbol{\beta}}_i)(\boldsymbol{\beta} - \widehat{\boldsymbol{\beta}}_i) = \left(\boldsymbol{m}(\widehat{\boldsymbol{\beta}}_i) - \boldsymbol{G}(\widehat{\boldsymbol{\beta}}_i)\widehat{\boldsymbol{\beta}}_i\right) - \left(-\boldsymbol{G}(\widehat{\boldsymbol{\beta}}_i)\boldsymbol{\beta}\right) \\ = \boldsymbol{v}_i - \boldsymbol{G}_i\boldsymbol{\beta} \end{aligned} \tag{29}$$

By inserting this solution to the Equation 26, the criterion function becomes $q = (\boldsymbol{v}_i - \boldsymbol{G}_i\boldsymbol{\beta})'\boldsymbol{W}(\boldsymbol{v}_i - \boldsymbol{G}_i\boldsymbol{\beta})$. Now an approximate for the estimator can be presented explicitly in linear form. This is shown in Equation 30.

$$\widehat{\boldsymbol{\beta}}_{i+1} = (\boldsymbol{G}_i{}'\boldsymbol{W}\boldsymbol{G}_i)^{-1}\boldsymbol{G}_i{}'\boldsymbol{W}\boldsymbol{v}_i \tag{30}$$

For the iteration, parameters need good starting values which lie close to the true values of the parameters. In the estimation, the given starting values for the parameters were based on the range of the expected values. All the parameter values were supposed to lie between zero and one because the variables were scaled to the range and for the conduct parameters this range was set by the theory. For each of the parameters, 0.5 was given as a starting value, and the signs were set in accordance with the economic theory.

The variance of the GMM estimator with an unspecified weighting matrix is shown in Equation 31 in which $\boldsymbol{S} = \boldsymbol{E}[\boldsymbol{m}(\boldsymbol{\beta})\boldsymbol{m}(\boldsymbol{\beta})']$.

$$\boldsymbol{V}(\boldsymbol{\beta}) = \frac{1}{n}\left(\boldsymbol{G}(\boldsymbol{\beta})'\boldsymbol{W}\boldsymbol{G}(\boldsymbol{\beta})\right)^{-\boldsymbol{1}}\boldsymbol{G}(\boldsymbol{\beta})'\boldsymbol{W}\boldsymbol{S}\boldsymbol{W}\boldsymbol{G}(\boldsymbol{\beta})\left(\boldsymbol{G}(\boldsymbol{\beta})'\boldsymbol{W}\boldsymbol{G}(\boldsymbol{\beta})\right)^{-\boldsymbol{1}} \tag{31}$$

If the optimal weighting matrix chosen, i.e. $\boldsymbol{S} = \boldsymbol{W}$, then Equation 31 can be reduced. This is shown in Equation 32. (Greene 2003, 540–544.)

$$\boldsymbol{V}(\boldsymbol{\beta}) = \frac{1}{n}\left(\boldsymbol{G}(\boldsymbol{\beta})'\boldsymbol{W}\boldsymbol{G}(\boldsymbol{\beta})\right)^{-\boldsymbol{1}} \tag{32}$$

The significance of a coefficient is based on the robust t-statistic which follows standard normal distribution. The statistic is presented in Equation 33 in which $\sqrt{\boldsymbol{V}(\boldsymbol{\beta})_{ii}}$ is the (*i*,*i*) block of the weighting matrix and *SE* refers to standard error. (Hayashi 2000, 211.)

$$t = \frac{\sqrt{n}\beta_{\boldsymbol{i}}}{\sqrt{\boldsymbol{V}(\boldsymbol{\beta})_{\boldsymbol{ii}}}} = \frac{\beta_{\boldsymbol{i}}}{\sqrt{\frac{1}{n}\boldsymbol{V}(\boldsymbol{\beta})_{\boldsymbol{ii}}}} = \frac{\beta_{\boldsymbol{i}}}{SE_i} \tag{33}$$

The efficiency of the GMM estimator is based on the optimal weighting matrix. On the other hand, a consistent estimator for $\boldsymbol{\beta}$ is needed to obtain an estimate for $\boldsymbol{W}$. For this reason, the efficient GMM estimation needs to be carried out at least in two-steps. In the first step, a positive definite matrix is applied as an initial weighting matrix to obtain an initial estimate for $\boldsymbol{\beta}$. It can be the identity matrix or the covariance matrix of the instruments. In the second step, an estimate for $\boldsymbol{\beta}$ is applied to obtain an estimate for $\boldsymbol{W}$. (Hayashi 2000, 212–213.) In the estimation, two-step estimation was applied and the identity matrix was set as the initial weighting matrix.

The overidentification test, i.e. the J-test, is a standard diagnostic in the GMM estimation. When a model is overidentified, all the moment conditions cannot simultaneously equal zero. The overidentification test shows whether the value of the criterion function is statistically close enough to zero. The test statistic is obtained by multiplying the value of the criterion function by the number of observations. If the model is correctly specified, the statistic follows the chi-square distribution. The degrees of freedom for the test are obtained by subtracting the number of parameters from the number of moment conditions. (Hall 2005, 144–145.)

The stationarity of the variables and the residuals were tested with the augmented Dickey-Fuller (ADF) test. The test statistic is presented in Equation 34.

$$\Delta y_t = \alpha_1 + \alpha_2\tau + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{34}$$

In Equation 34, term y_t denotes some variable at time *t*, Δy_t the difference between present and some past value at *t-i*, α_1 the constant term, α_2 the coefficient for deterministic time trend τ and, ε_t the white-noise error. The test discovers whether the null-hypothesis, $\gamma=0$, is true. If it is true, there is a unit root and the process is not stationary. Lagged differences are included to the model until the error becomes a white noise process. (Asteriou and Hall 2007, 279.) Because the variables were deflated in the estimation, trend τ in Equation 34 was ignored.

The parametric restrictions are tested with the Wald test. The test statistic in the case of nonlinear restrictions is shown in Equation 35 in which $\boldsymbol{a}(\boldsymbol{\beta})$ is a vector of parametric restrictions.

$$Wald = n\boldsymbol{a}(\boldsymbol{\beta})'(\boldsymbol{A}(\boldsymbol{\beta})\boldsymbol{V}(\boldsymbol{\beta})\boldsymbol{A}(\boldsymbol{\beta})')^{-\mathbf{1}}\boldsymbol{a}(\boldsymbol{\beta}) \tag{35}$$

The restrictions are given in form $\boldsymbol{a}(\boldsymbol{\beta}) = 0$. Term $\boldsymbol{A}(\boldsymbol{\beta})$ is the matrix of the first derivatives of $\boldsymbol{a}(\boldsymbol{\beta})$. The size of the matrix is the restrictions times the total number of moment conditions. The test statistic follows the chi-square distribution. The number of degrees of freedom is the number of restrictions. (Hayashi 2000.)

The empirical analysis implies testing which of the models fits best to the data. It was noted in the previous chapter that the BPT model can be derived from the MPT and the RPT model through parametric restrictions but a different strategy needs to be applied to compare the MPT and the RPT model. Two models are non-nested if a model cannot be obtained as a special case of another (Hall 2005, 194). Hall (2005, 194) divides the tests for non-nested hypotheses into two categories. First, nested models are structured as generalizations to comprehend different non-nested models as the special cases of the nested model. This is the idea of the NST model. The second category includes the tests in which the results from a model are explained by another. Schroeter et al. (2000) note that the NST model has no clear economic interpretation, and therefore it might be problematic if the model would reveal to be the best. Nevertheless, Hall (2005) mentions two tests from the second category and does not recommend using neither of them in the GMM context.

The models can be compared with a goodness-of-fit based approach. Model and Moment Selection Criteria (MMSC) by Andrews and Lu (2001) was applied in the estimation. MMSC are based on the J-statistic, and the selection criteria penalize the addition of parameters and reward the addition of moment conditions. A specification with the lowest value is considered as the best. MMSC are analogous to the three information criteria which are commonly used in the maximum likelihood context. MMSC are named after them. The three criteria are

$\boldsymbol{MMSC\text{–}BIC}: J(b,c) - (|c| - |b|)\ln n$

$\boldsymbol{MMSC\text{–}AIC}: J(b,c) - 2(|c| - |b|)\ln n$

$\boldsymbol{MMSC\text{–}HQIC}: J(b,c) - Q(|c| - |b|)\ln\ln n$

Term $J(\cdot)$ is the J-statistic of a GMM model, $|c|$ is the number of moment conditions and $|b|$ the number of parameters. Term Q is some number greater than two. Following Andrews and Lu (2001), the value of 2.1 was used in the estimation.

4.3 Data

In Equation 12, the consumer price of meat products was used as x_2 and disposable income as x_3. The sum of wages paid in the whole economy served as an approximate for the disposable income. In Equation 13, the sum of wages paid in the retail sector served as w_2. In Equation 14, the sum of wages paid in the food processing sector served as v_2 and the producer price of raw cow milk as v_3.

The consumer price of dairy products served as an approximate for the retail price, and the producer price of the dairy processing sector served as an approximate for the wholesale price of dairy products. The latter series shows the development of prices in the domestic markets including both domestically produced and imported products. The price indices are presented in Figure 3. The volume of the production in the dairy processing sector was used as an approximate for the quantity.

Three dummy variables were included to capture additional shocks in the supply. The first variable captured the impact of the global food crisis in 2007–2008. At that time, also other commodity prices increased making the cost of production more expensive through higher input prices. A starting and an ending point for the period were selected based on changes in the prices. The wholesale and the consumer price started to increase rapidly in November 2007 and to decrease in September 2009. This can be clearly seen from Figure 3. The second dummy variable covered the period of Valio's predatory pricing. According to the report of Finnish Competition and Consumer Authority (Kilpailuvirasto 2012) Valio started it in March 2010 and ended it in December 2012. The third variable captured the impact of the embargo between the EU and Russia which started in August 2014. All the variables are listed in Table 4.

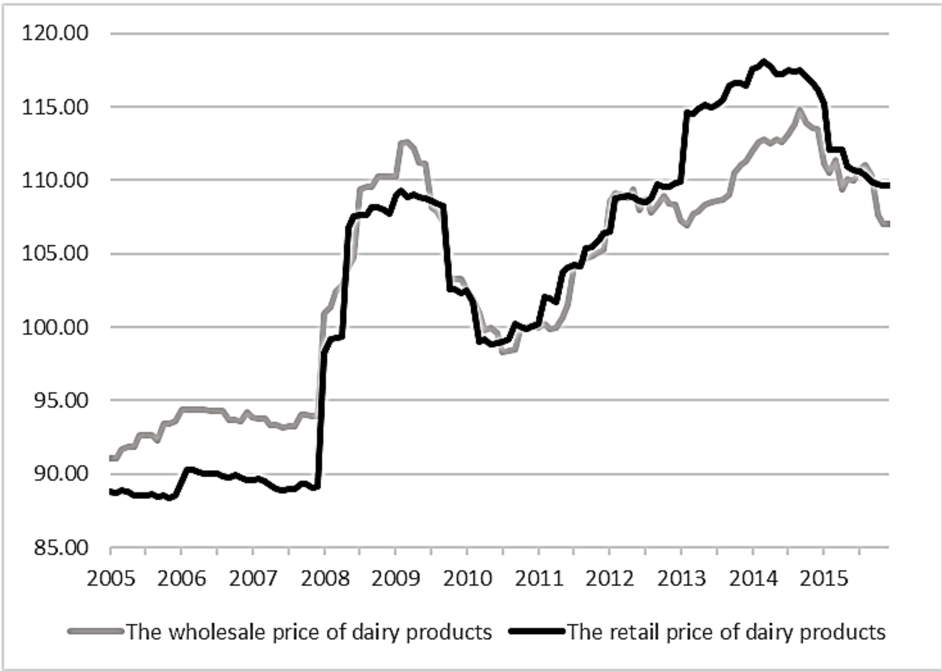

Figure 3. The wholesale and the retail price of dairy products

Statistics Finland provided the whole data set.[1] There were 132 observations, and the data covered the period from January 2005 to December 2015. The variables were obtained in index form, and they were deflated by dividing them by the consumer price index. The variables had 2010 as the base year. The retail price of dairy products was calculated by combining all the dairy product categories. In the aggregate series, all the individual categories were weighted using the same weights as in the general consumer price index. The weights were provided by Statistic Finland (Statistics Finland b). All the variables were scaled to lie around one to ensure the proximity of the starting values and the true parameter values. The volume index of the production was divided by 100, whereas all the monetary values were already at the right range after the deflation.

[1] To obtain the publicly available series

http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/?rxid=fac5971b-320e-4ec6-9863-35f813758864
Data on consumer prices: Prices and Costs >> Consumer price index >> Consumer Price Index 2010=100/ Consumer Price Index 2005=100
Data on producer prices: Prices and Costs >> Producer price indices >> Producer Price Indices 2010=100 (TOL2008)
The producer price of raw milk: Prices and Costs >> Index of producer prices of agricultural products >> Index of producer prices of agricultural products 2010=100
Data on wages: Wages, Salaries and Labor Costs >> Wage and salary indices >> Wage and salary indices by industry 2010=100 (TOL 2008)

Table 4. A list of variables

Term	Variable
q	The quantity of dairy products
p_w	The wholesale price of dairy products
p_r	The retail price of dairy products
x_2	The price of meat products
x_3	Disposable income
w_2	The cost of labor in the retail sector
v_2	The cost of labor in the dairy processing sector
v_3	The producer price of raw milk
d_1	The variable capturing the impact of the food crisis
d_2	The variable capturing the impact of the predatory pricing
d_3	The variable capturing the impact of the trade embargo

5 Results

The estimation revealed that the dummy variable for the trade embargo was not significant and it was excluded from the final specification. This finding could be explained as a delay in the actual impact of the embargo. Another explanation could be that the domestic market was able to absorb the sudden increase in the supply. The overall performance of the final specification seemed plausible. Most of the variables were statistically significant and signs of the coefficients were consistent with the economic theory. The results are presented in Tables 8–11.

ADF test results for the variables with 12, 18 and 24 lags are presented in Table 5. Most of the variables, if not all of them, were I(1)-processes, i.e. first-difference stationary. The null-hypothesis for the variables in levels was consistently accepted with and without the constant in the case of 18 lags. With 24 lags, the null was rejected only in the case of x_3, i.e. disposable income. The variable was stationary at 5% level when the constant was included but the null was not rejected when the constant was excluded from the specification. In the case of 12 lags and no constant, the null for the variables in first differences was rejected at 1% level except in the case of v_3, i.e. the price of raw milk, in which the rejection was at 5% level. Except for v_3, the null was also rejected at least at 10% level in the case of 12 lags and the constant. However, the null for v_3 in the first differences was rejected at 5% level in the case of 18 lags and the constant and at 1% level in the case of 18 lags and no constant

Table 5. The ADF test results for the variables

	Lags	Constant	No constant		Lags	Constant	No constant
	12	-1.195	0.780		12	-2.775 *	-2.711 ***
q	18	-1.369	0.703	Δq	18	-3.268 **	-3.056 ***
	24	-1.339	0.556		24	-2.002	-1.801 *
	12	-2.732 *	-0.356		12	-3.124 **	-3.139 ***
p_p	18	-2.228	-0.049	Δp_p	18	-3.344 **	-3.363 ***
	24	-1.709	-0.025		24	-2.647 *	-2.665 ***
	12	-2.588 *	-0.027		12	-2.576 *	-2.598 ***
p_r	18	-2.240	0.364	Δp_r	18	-3.167 **	-3.142 ***
	24	-2.015	0.667		24	-2.780 *	-2.688 ***
	12	-1.757	0.235		12	-2.890 **	-2.869 ***
x_2	18	-1.823	0.383	Δx_2	18	-2.140	-2.118 **
	24	-1.371	0.530		24	-2.026	-1.945 *
	12	-4.218 ***	2.851 ***		12	-4.008 ***	-3.605 ***
x_3	18	-2.410	0.915	Δx_3	18	-2.285	-2.054 **
	24	-3.242 **	1.294		24	-2.487	-2.287 **
	12	-2.082	3.598 ***		12	-3.897 ***	-2.625 ***
w_2	18	-1.540	0.655	Δw_2	18	-1.453	-1.219
	24	-1.912	1.097		24	-1.485	-1.055
	12	-0.481	1.180		12	-6.757 ***	-6.697 ***
v_2	18	-1.095	0.747	Δv_2	18	-3.033 *	-2.946 ***
	24	-0.341	1.292		24	-3.826 ***	-3.579 ***
	12	-2.948 *	-0.558		12	-2.241	-2.210 **
v_3	18	-2.118	-0.474	Δv_3	18	-3.011 **	-3.004 ***
	24	-2.115	-0.526		24	-2.176	-2.165 **

* : p-value < 0.1
** : p-value < 0.05
*** : p-value < 0.01

The stationarity of the residuals was similarly tested but, in this case, the constant was not included to the test specifications. The results are provided in Table 6. The presence of unit root was rejected in all the cases at least at 5% level in the case of 12 lags. In the case of 18 and 24 lags, all the residuals were stationary, i.e. I(0), at least at 10% level. The I(1) variables seemed to be cointegrated because all the residuals were stationarity. This implies that the results of the estimated models were not spurious.

Table 6. The ADF test results for the residuals

BPT

Residuals	Lags	Test statistic
Equation 1	12	-2.718 ***
	18	-2.211 **
	24	-1.79 *
Equation 2	12	-2.091 **
	18	-1.814 *
	24	-1.686 *
Equation 3	12	-3.72 ***
	18	-2.497 **
	24	-2.382 **

MPT

Residuals	Lags	Test statistic
Equation 1	12	-2.728 ***
	18	-2.212 **
	24	-1.804 *
Equation 2	12	-2.093 **
	18	-1.803 *
	24	-1.687 *
Equation 3	12	-3.718 ***
	18	-2.47 **
	24	-2.362 **

RPT

Residuals	Lags	Test statistic
Equation 1	12	-2.765 ***
	18	-2.56 **
	24	-2.074 **
Equation 2	12	-2.135 **
	18	-1.831 *
	24	-1.76 *
Equation 3	12	-3.656 ***
	18	-2.642 ***
	24	-2.104 **

NST

Residuals	Lags	Test statistic
Equation 1	12	-2.762 ***
	18	-2.656 ***
	24	-2.118 **
Equation 2	12	-2.153 **
	18	-1.805 *
	24	-1.783 *
Equation 3	12	-3.605 ***
	18	-2.572 **
	24	-1.963 **

* : p-value < 0.1
** : p-value < 0.05
*** : p-value < 0.01

The estimates were consistent between the four models, and the null of the overidentification test was not rejected in any of the cases (Tables 8–11). The systems were thus correctly specified. In the BPT model, the value of the J-statistic was 12.02 and the respective probability value was 0.284. In other models, the probability values ranged from 0.218 to 0.381. The BPT model had the lowest value in MMSC–BIC and in MMSC–HQIC, but MMSC–AIC value was lowest in the RPT model (Table 7).

Parametric restrictions needed to be considered in order to choose between the BPT and the RPT model. The probability value of γ is 0.219 in the RPT model and thus insignificant (Table 10). In the case of the NST model, the probability value of the Wald test statistic was 0.199 for the null hypothesis that parameters δ and γ equal zero simultaneously (Table 12). The null hypotheses of the parametric restrictions were not rejected in any of the models and this leads to the conclusion that the BPT model should be considered as the best. This implies that the wholesale market is competitive.

Table 7. The MMSC values

	MMSC–BIC	MMSC–AIC	MMSC–HQIC
BPT	-36.81 *	-7.98	-21.28 *
MPT	-32.02	-6.08	-18.05
RPT	-34.31	-8.37 *	-20.34
NST	-30.21	-7.15	-17.79

Parameter a_1, which relates to the quantity in Equation 12, was negative and therefore correctly specified (Tables 8–11). The value of the parameter was -0.557 in the BPT model, while the value ranged from -0.489 to -0.548 in other models. Parameter a_2, which relates to x_2 in Equation 12, had positive sign implying that meat products are complements to dairy products (Tables 8–11). The value ranged from 0.261 to 0.351 but it was significant only in the NST model with the probability value of 0.053. Parameter a_3, which relates to x_3 and quantity in Equation 12, had positive sign as expected (Tables 8–11). This implies that wealthier consumers have more elastic demand for dairy products.

Parameter b_1, which relates to the quantity in Equation 13, had negative sign (Tables 8–11). This may indicate increasing returns to scale in the retail sector. As shown in Section 3.2, concentration on the sector has increased, and increasing returns to scale may explain the concentration. The value was -0.341 in the BPT model and ranged from -0.278 to -0.339 in other models. Parameter b_2, which relates to w_2 in Equation 13, had positive sign as expected (Tables 8–11). This implies that the cost of production increases as the cost of labor increases. The value ranged from 0.235 to 0.326.

Parameter c_1, which relates to the quantity in Equation 14, had negative sign in the NST model but positive sign in other models (Table 8–11). The value was 0.059 in the BPT model and ranged from -0.003 to 0.06 in other models. However, the significance of the parameter was questionable. The probability value was slightly over 0.1 in the BPT and the MPT model but over 0.8 in the RPT and the NST model. This finding suggests that changes in the price have only negligible effect on quantity supplied. This may relate to the fact that the production of dairy products cannot be quickly adjusted as the price changes because the production is closely tied to the supply of raw milk. Parameter c_2, which relates to v_2 in Equation 14, had positive sign as expected (Tables 8–11). The parameter was significant at 5% level only in the NST model, but the probability value was over 0.1 in other models. The value ranged from 0.013 to 0.185. Parameter c_3, which relates to v_3 in Equation 14, had positive sign (Tables 8–11). This implies that the supply becomes more inelastic as the price of raw milk increases.

It was noted that the two dummy variables had significant effect on the results. Parameter c_{01}, which relates to d_1 in Equation 14, had positive sign as expected, and the value ranged from 0.72 to 0.75 (Tables 8–11). This implies that the marginal cost of production was higher in the period from November 2007 to September 2009. Parameter c_{02}, which relates to d_2 in Equation 14, was assumed to decrease the generic wholesale price of dairy products although only one product category was affected. The sign was negative implying that the wholesale price was lower during the predatory pricing (Tables 8–11). The parameter value ranged from -0.038 to -0.041.

Table 8. The results of the BPT model

Parameter	**Value**	**Standard error**	**Test statistic**	**P-value**	**Confidence interval 95 %**
λ	1.298	0.367	3.540	0.000	[0.579 , 2.016]
a_0	1.007	0.168	5.980	0.000	[0.677 , 1.337]
a_1	-0.557	0.123	-4.540	0.000	[-0.797 , -0.316]
a_2	0.261	0.172	1.520	0.130	[-0.077 , 0.598]
a_3	0.285	0.079	3.610	0.000	[0.131 , 0.440]
b_0	-0.334	0.033	-10.100	0.000	[-0.399 , -0.269]
b_1	-0.341	0.102	-3.330	0.001	[-0.542 , -0.140]
b_2	0.326	0.046	7.030	0.000	[0.235 , 0.417]
c_0	0.879	0.038	23.420	0.000	[0.805 , 0.953]
c_1	0.059	0.036	1.620	0.105	[-0.012 , 0.130]
c_2	0.013	0.024	0.560	0.578	[-0.033 , 0.060]
c_3	0.078	0.024	3.320	0.001	[0.032 , 0.125]
c_{01}	0.072	0.007	9.930	0.000	[0.058 , 0.086]
c_{02}	-0.038	0.005	-7.060	0.000	[-0.049 , -0.028]
J-statistic:			12.020	0.284	

Table 9. The results of the MPT model

Parameter	Value	Standard error	Test statistic	P-value	Confidence interval 95 %
λ	1.298	0.396	3.280	0.001	[0.522 , 2.074]
δ	0.018	0.246	0.070	0.942	[-0.463 , 0.499]
a_0	0.991	0.177	5.590	0.000	[0.643 , 1.338]
a_1	-0.548	0.126	-4.350	0.000	[-0.794 , -0.301]
a_2	0.276	0.179	1.540	0.123	[-0.075 , 0.627]
a_3	0.277	0.081	3.400	0.001	[0.117 , 0.436]
b_0	-0.328	0.033	-10.070	0.000	[-0.392 , -0.264]
b_1	-0.339	0.119	-2.840	0.005	[-0.573 , -0.105]
b_2	0.315	0.045	7.030	0.000	[0.227 , 0.403]
c_0	0.877	0.038	23.270	0.000	[0.803 , 0.951]
c_1	0.060	0.037	1.610	0.106	[-0.013 , 0.133]
c_2	0.016	0.024	0.640	0.519	[-0.032 , 0.063]
c_3	0.077	0.029	2.660	0.008	[0.020 , 0.134]
c_{01}	0.072	0.007	9.590	0.000	[0.057 , 0.086]
c_{02}	-0.039	0.005	-7.090	0.000	[-0.049 , -0.028]
J-statistic:			11.924	0.218	

Table 10. The results of the RPT model

Parameter	Value	Standard error	Test statistic	P-value	Confidence interval 95 %
λ	1.143	0.355	3.220	0.001	[0.447 , 1.839]
γ	0.241	0.196	1.230	0.219	[-0.143 , 0.624]
a_0	0.966	0.178	5.410	0.000	[0.617 , 1.316]
a_1	-0.523	0.122	-4.270	0.000	[-0.763 , -0.283]
a_2	0.294	0.180	1.630	0.103	[-0.059 , 0.648]
a_3	0.260	0.084	3.080	0.002	[0.095 , 0.426]
b_0	-0.290	0.040	-7.300	0.000	[-0.368 , -0.212]
b_1	-0.268	0.102	-2.640	0.008	[-0.467 , -0.069]
b_2	0.261	0.052	5.030	0.000	[0.160 , 0.363]
c_0	0.694	0.136	5.090	0.000	[0.427 , 0.961]
c_1	0.013	0.057	0.220	0.825	[-0.099 , 0.124]
c_2	0.147	0.096	1.520	0.128	[-0.042 , 0.335]
c_3	0.107	0.034	3.100	0.002	[0.039 , 0.174]
c_{01}	0.075	0.008	9.440	0.000	[0.059 , 0.090]
c_{02}	-0.040	0.008	-5.240	0.000	[-0.055 , -0.025]
J-statistic:			9.633	0.381	

Table 11. The results of the NST model

Parameter	Value	Standard error	Test statistic	P-value	Confidence interval 95 %
λ	1.182	0.426	2.770	0.006	[0.347 , 2.017]
δ	0.129	0.221	0.580	0.561	[-0.305 , 0.562]
γ	0.336	0.214	1.570	0.116	[-0.083 , 0.755]
a_0	0.906	0.185	4.880	0.000	[0.542 , 1.269]
a_1	-0.489	0.125	-3.910	0.000	[-0.734 , -0.244]
a_2	0.351	0.181	1.940	0.053	[-0.004 , 0.705]
a_3	0.228	0.081	2.820	0.005	[0.069 , 0.387]
b_0	-0.275	0.035	-7.900	0.000	[-0.343 , -0.207]
b_1	-0.278	0.117	-2.380	0.017	[-0.507 , -0.049]
b_2	0.235	0.042	5.640	0.000	[0.154 , 0.317]
c_0	0.648	0.128	5.050	0.000	[0.396 , 0.900]
c_1	-0.003	0.068	-0.040	0.964	[-0.135 , 0.129]
c_2	0.185	0.093	1.990	0.047	[0.003 , 0.368]
c_3	0.103	0.041	2.530	0.012	[0.023 , 0.184]
c_{01}	0.073	0.009	8.220	0.000	[0.055 , 0.090]
c_{02}	-0.041	0.008	-5.210	0.000	[-0.056 , -0.025]
J-statistic:			8.853	0.355	

The results indicated the presence of market power on the retail market. Parameter λ was statistically significant in all the models (Tables 8–11). The estimate was 1.298 in the BPT model and ranged from 1.143 to 1.298 in the rest of the models. This implies that the retail market is characterized by collusive behavior. The estimate exceeded the value of full mark-up, i.e. one, although the theory limits the value to be one at most. It thus became necessary to test further whether the value could statistically equal one. All the 95% confidence intervals include one (Tables 8–11), and the probability values of the Wald test statistics varied from 0.417 in the BPT model to 0.687 in the RPT model (Table 12). None of the tests rejected the null-hypothesis, i.e. parameter λ equals one.

Parameter δ was 0.018 in the MPT model (Table 9) and 0.129 in the NST model (Table 11). However, the parameter was not significant in either case. This implies that retailers have no market power over processors. Estimates for parameter γ were 0.241 in the RPT model and 0.336 in the NST model. The probability value of the parameter was 0.219 in the RPT model and 0.116 in the NST model. The parameter was significant at the 12% level in the NST model which could be considered as a modest evidence for market power. However, the evidence should have been confirmed by the results of the RPT model and by MMSC but this was not the case. Therefore according to the results, the wholesale market of dairy products is competitive but the retail market is characterized by high degree of market power.

Table 12. Summary on parametric restrictions

Model		**Wald statistic**	**P-value**
BPT	$h_0: \lambda = 1$	0.66	0.417
MPT	$h_0: \lambda = 1$	0.56	0.452
RPT	$h_0: \lambda = 1$	0.16	0.687
NST	$h_0: \lambda = 1$	0.18	0.669
NST	$h_0: \gamma = \delta = 0$	3.23	0.199

6 Conclusions and Discussion

This study examined whether the processors and the retailers have market power in the Finnish dairy chain. The analysis considered the wholesale and the retail market of dairy products. The dairy processing and the retail sector in Finland are highly concentrated,and strong presumptions about market power would have been misleading. The study of IO and NEIO provided methodological framework for the study. The approach by Schroeter et al. (2000) was applied in the empirical analysis, and the estimation was carried out using GMM. The results indicate that the retailers have market power over the consumers, but there was no evidence for market power in the wholesale market. According to the estimates, retailers employ full mark-up in the retail market, and the market is thus characterized by collusive behavior.

Importance of further research is emphasized for three reasons. Firstly, Perekhozhuk et al. (2016) remind that the results of a NEIO model may be sensitive and propose comparing different specifications and estimation methods. It is left for the future research whether the results of this study are sensitive towards different models and estimation methods. Another reason is that different approaches allow relaxing some of the restrictive assumptions of the approach of Schroeter et al. (2000). Ideally, panel data should be applied as discussed by Kaiser and Suzuki (2006, 347). Dynamic models would allow observing temporal changes in market power and short run dynamics in general. Furthermore, linear supply and demand functions could be replaced by e.g. transcendental logarithmic function or almost ideal demand system. Also, maximum likelihood or some other estimation method could be used instead of GMM.

Instead of considering dairy products as a generic group, the research could focus on a certain product, on fluid milk products for example. However, the availability of appropriate data is expected to limit the future research. Unfortunately, this problem is not a market specific, and a researcher has very limited opportunities to obtain better data. As noted by Bresnahan (1989), NEIO has not oriented in detecting the causes of market power. Also in this study, the degree of market power was measured but the causes for market power are out of the scope of the approach used in this study. Therefore, the causes of market power could be further examined with another method.

Thirdly, the attempts to examine market power in the Finnish dairy are currently few. Three earlier studies, which examined the degree of competition in the Finnish dairy chain, were found as reference for this study. The study by Kotilainen et al. (2010) cannot be directly compared with this study because the approaches were substantially different. This study was not aimed to estimate the dynamic development of market power and therefore cannot say anything about changes in the degree of competition. Ulvinen (2006) provided a Lerner index value for the dairy processing sector and concluded that the sector is competitive. To some extent, this finding is consistent with the results of this study. Čechura et al. (2015) found, on the other hand, that the Finnish dairy processing sector have market power over the retailers and the consumers. This result was not confirmed by this study.

The findings of this study further imply that the consumers are worse off. The high degree of market power may affect, not only to the consumers, but also to the processors and the producers. Peltoniemi et al. (2015) showed that the wholesale–retail sector had increased its relative share from the consumer price of dairy products during 2008–2012. This finding supports the current conclusion about retailers' market power, although market power should not be considered as the only reason for the grown margin. The question remains whether the prices of dairy products are about to decrease in Finland? To some extent, the correction already happened in 2015 (see e.g. Nielsen 2016). However, a public debate remains whether a retail driven discount in food prices was made at the expense of the retailers or the producers (see e.g. Ryynänen 2016; MTV 2015).

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Appendix 1: Full Derivation of the Models

The following calculation shows in detail how to obtain Equation 15.

$$mr_r = \frac{\partial p_r q}{\partial q} = \frac{\partial (a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon) q}{\partial q}$$
$$= \frac{\partial (a_0 q + a_1 q^2 + a_2 x_2 q + a_3 x_3 q^2 + \epsilon q)}{\partial q}$$
$$= a_0 + 2a_1 q + a_2 x_2 + 2a_3 x_3 q + \epsilon$$
$$= (a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon) + (a_1 + a_3 x_3) q$$
$$= p_r + (a_1 + a_3 x_3) q = p_r + \frac{\partial p_r}{\partial q} q = p_r + \frac{\partial p_r}{\partial q} q \frac{p_r}{p_r} = p_r \left(1 + \frac{1}{\varepsilon}\right)$$

The derivation of the conduct parameter was shown in Section 2.3. At this point, the average conduct parameter λ is simply added to the expression to make it corresponding to the content of Equation 7. It needs to be reminded though that the conduct parameter of firm *i* in Equation 7 needs to be considered as an average conduct.

$$p_r \left(1 + \frac{1}{\varepsilon}\right) \Rightarrow p_r \left(1 + \frac{\lambda}{\varepsilon}\right) = p_r + \lambda (a_1 + a_3 x_3) q$$

The equilibrium condition in the BPT model states that $mc_p = nmr_r$. The following calculation shows in detail how to obtain Equation 17.

$$c_0 + c_1 q + c_2 v_2 + c_3 v_3 q + \sum_{i=1}^{n} c_{0i} d_i + \mu = p_r + \lambda (a_1 + a_3 x_3) q - (b_0 + b_1 q + b_2 w_2 + \eta)$$

$$p_r = -\lambda (a_1 + a_3 x_3) q + b_0 + b_1 q + b_2 w_2 + \eta + c_0 + c_1 q + c_2 v_2 + c_3 v_3 q + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r = [-\lambda (a_1 + a_3 x_3) + b_1 + c_1 + c_3 v_3] q + b_0 + c_0 + b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \eta + \mu$$

$$p_r = -[\lambda (a_1 + a_3 x_3) - (b_1 + c_1) - c_3 v_3] q + (b_0 + c_0) + b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu)$$

The following calculation shows in detail how to obtain Equation 18.

$$me_r = \frac{\partial p_w q}{\partial q} = \frac{\partial(c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu)q}{\partial q}$$

$$= \frac{\partial(c_0 q + (c_1 + c_3 v_3)q^2 + c_2 v_2 q + \sum_{i=1}^{n} c_{0i} d_i\, q + \mu)}{\partial q}$$

$$= c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu + (c_1 + c_3 v_3)q = p_w + (c_1 + c_3 v_3)q$$

The conduct parameter is added.

$$me_r = p_w + \delta(c_1 + c_3 v_3)q$$

$$= c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu + \delta(c_1 + c_3 v_3)q$$

$$= c_0 + (1 + \delta)(c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

The equilibrium condition in the MPT model states that $me_r = nmr_r$. The following calculation shows in detail how to obtain Equation 19.

$$c_0 + (1 + \delta)(c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu = p_r + \lambda(a_1 + a_3 x_3)q$$
$$-(b_0 + b_1 q + b_2 w_2 + \eta)$$

$$p_r = -\lambda(a_1 + a_3 x_3)q + b_0 + b_1 q + b_2 w_2 + \eta + c_0 + (1 + \delta)(c_1 + c_3 v_3)q$$
$$+ c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r = -[\lambda(a_1 + a_3 x_3) - (b_1 + (1 + \delta)c_1) - (1 + \delta)c_3 v_3]q + (b_0 + c_0)$$
$$+ b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu)$$

The following calculation shows in detail how to obtain Equation 20.

$$mr_p = \frac{\partial p_w q}{\partial q} = \frac{\partial nmr_r q}{\partial q} = \frac{\partial\big(p_r + \lambda(a_1 + a_3 x_3)q - (b_0 + b_1 q + b_2 w_2 + \eta)\big)q}{\partial q}$$

$$= \frac{\partial(p_r q + \lambda(a_1 + a_3 x_3)q^2 - b_0 q - b_1 q^2 - b_2 w_2 q - \eta q)}{\partial q}$$

$$= \frac{\partial\big((a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon)q + \lambda(a_1 + a_3 x_3)q^2 - b_0 q - b_1 q^2 - b_2 w_2 q - \eta q\big)}{\partial q}$$

$$= \frac{\partial(a_0 q + a_1 q^2 + a_2 x_2 q + a_3 x_3 q^2 + \epsilon q + \lambda(a_1 + a_3 x_3)q^2 - b_0 q - b_1 q^2 - b_2 w_2 q - \eta q)}{\partial q}$$

$$= a_0 + 2a_1 q + a_2 x_2 + 2a_3 x_3 q + \epsilon + 2\lambda(a_1 + a_3 x_3)q - b_0 - 2b_1 q - b_2 w_2 - \eta$$

$$= a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon + \lambda(a_1 + a_3 x_3)q - b_0 - b_1 q - b_2 w_2 - \eta + \lambda(a_1 + a_3 x_3)q$$
$$+ a_1 q + a_3 x_3 q - b_1 q$$

$$= nmr_r + (a_1 + a_3 x_3 + \lambda(a_1 + a_3 x_3) - b_1)\, q$$

$$= nmr_r + \big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q$$

The conduct parameter is added.

$$nmr_r + \gamma(a_1 + a_3 x_3 + \lambda(a_1 + a_3 x_3) - b_1)\, q$$

The equilibrium condition in the RPT model states that $mr_p = mc_p$. The following calculation shows in detail how to obtain Equation 21.

$$nmr_r + \gamma\big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q = c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$a_0 + a_1 q + a_2 x_2 + a_3 x_3 q + \epsilon + \lambda(a_1 + a_3 x_3)q - b_0 - b_1 q - b_2 w_2 - \eta$$
$$+ \gamma\big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q = c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r + \lambda(a_1 + a_3 x_3)q - b_0 - b_1 q - b_2 w_2 - \eta + \gamma\big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q = c_0$$
$$+ (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r = -\lambda(a_1 + a_3 x_3)q + b_0 + b_1 q + b_2 w_2 + \eta - \gamma\big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q + c_0$$
$$+ (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r = -\lambda(a_1 + a_3 x_3)q + b_0 + b_1 q + b_2 w_2 + \eta - \gamma\big((1 + \lambda)(a_1 + a_3 x_3) - b_1\big)q$$
$$+ c_0 + (c_1 + c_3 v_3)q + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + \mu$$

$$p_r = -\big[\big(\gamma + \lambda(1 + \gamma)\big)(a_1 + a_3 x_3) - (b_1(1 + \gamma) + c_1) - c_3 v_3\big]q + (b_0 + c_0)$$
$$+ b_2 w_2 + c_2 v_2 + \sum_{i=1}^{n} c_{0i} d_i + (\eta + \mu)$$

In the RPT model, the equilibrium price in the wholesale market is determined by the net marginal revenue of the retailers. The following calculation shows in detail how to obtain Equation 22 using Equation 16 and 21.

$$p_w = nmr_r$$

$$p_w = p_r + \lambda(a_1 + a_3x_3)q - (b_0 + b_1q + b_2w_2 + \eta)$$

$$p_w = -\big[\big(\gamma + \lambda(1+\gamma)\big)(a_1 + a_3x_3) - (b_1(1+\gamma) + c_1) - c_3v_3\big]q + (b_0 + c_0) + b_2w_2 + c_2v_2 + \sum_{i=1}^{n} c_{0i}d_i + (\eta + \mu) + \lambda(a_1 + a_3x_3)q - (b_0 + b_1q + b_2w_2 + \eta)$$

$$p_w = -\gamma(a_1 + a_3x_3)q - \lambda(a_1 + a_3x_3)q - \gamma\lambda(a_1 + a_3x_3)q + b_1q + \gamma b_1q + c_1q + c_3v_3q - b_1q + \lambda(a_1 + a_3x_3)q + c_0 + c_2v_2 + \sum_{i=1}^{n} c_{0i}\, d_i + \mu$$

$$p_w = -\gamma(a_1 + a_3x_3)q - \gamma\lambda(a_1 + a_3x_3)q + \gamma b_1q + c_1q + c_3v_3q + c_0 + c_2v_2 + \sum_{i=1}^{n} c_{0i}\, d_i + \mu$$

$$p_w = -[\gamma(1+\lambda)(a_1 + a_3x_3) - (b_1\gamma + c_1) - c_3v_3]q + c_0 + c_2v_2 + \sum_{i=1}^{n} c_{0i}\, d_i + \mu$$